Remarks/Arguments

Applicant appreciates the feedback received from Examiner Bitar in the "Detailed Action" of the Office communication.

Claim Rejections – 35 USC §112

Claim 6 is cancelled.

Claim Objections

Claim 17 is amended to delete one of the repeated "or".

Double Patenting

Examiner Bitar rejected claims 1, 14, 17 and 20 under the judicially created doctrine of obviousness-type double patenting as being unpatenable over claims 1-6 of US Patent No. 7,110,603B2.

Applicant respectfully responds as follows:

I. The claimed inventions are different

A. US Patent No. 7,110,603B2

The invention of US Patent No. 7,110,603B2 decomposes a template into multiple compact shaped components and performs search using separate rotation and scale invariant profiles for each component. It then synthesizes the search results for the complete template or partial template using the component search results. The objective of the invention is to handle templates of arbitrary shapes. The other objective of the invention is to support reliable partial shape search. Another objective of the invention is to reduce false matches.

A key element of the invention is the refined invariant match method, which applies **transformation** (such as affine) to the pattern template according to the scale, rotation angle, and location contained in the match result. After performing transformation on the pattern template, the **conventional matching method can be directly applied** to obtain the matching score. The refined matches with high matching scores are confirmed to be the refined invariant matches. So the key invention is template transformation, re-applied transformed template to image pixels (of the input image or a small candidate image region) for matching.

B. Current invention

This invention provides a fast method for high precision matching with the equivalent subpixel and subsampling interpolation in the image or template domain **without** actual performing template **transformation** such as the subpixel interpolation and/or subsampling. It achieves the high precision through sampling parameter optimization.

Therefore, very fine sampling precision can be accomplished **without** the difficulty of high resolution image/template storage and expensive computation for template transformation and **actual image matching** at high resolution.

C. Patentable Difference
The main patentable difference of the two refined matching methods are
(a) With (prior art) or without (current invention) the need for template transformation
(b) With (prior art) or without (current invention) the need for template matching on images

D. Claim amendments
We amended the independent claims 1, 14, 17 and 20 to clearly state the unique inventive steps of the current invention. Specifically, we added the following limitations
- Initial search result output containing only matching function values at discrete (x,y) positions
- Perform high precision match by high precision matching function maximization directly using the matching function values at discrete (x,y) positions without image matching.

Based on the above explanations and claims amendment, the applicant respectfully submits that the double patenting rejection is overcome.

Claim Rejections – 35 USC §103

Examiner Bitar rejected claims 1, 6, 11, 14, 17, 20, and 23 under USC §103(a) as being unpatentable over the combination of Kurosawa et al (U.S. Patent 4,972,499), Silver et al (U.S. Patent 7,164,796) and McConnell (U.S. Patent 4,567,610).

Applicant respectfully submit that the current invention are not covered by the prior arts even in its best combination.

A. Kurosawa
Kurosawa discloses a pattern recognition apparatus having a contour segmentation unit for dividing an input pattern into segments, a characteristic extraction unit for extracting characteristics of the input segments, and a reference unit for storing characteristic data of reference patterns. The reference unit includes a main reference and a detailed matching reference. The main reference stores partial pattern characteristic data representing the characteristics of segments of each reference pattern. The detailed matching reference stores detailed characteristic data of each reference pattern together with a program for specifying an operation procedures. A matching processor sequentially compares and collates the input pattern with the reference patterns to find out that standard pattern with which the input pattern is matched with the highest similarity. When the input pattern is matched with **several** reference patterns, a detailed recognition unit performs a detailed recognition process using the detailed characteristic data of these reference patterns to

finally select the **correct one** from among the reference patterns. The main reference additionally stores identification marks to identify specific reference segments necessary to acquired the above detailed characteristic data.

Comments: *Kurosawa focuses on pattern recognition rather than high precision matching. Its detailed recognition module is for ambiguity character recognition rather than sub-pixel high precision matching.*

B. McConnell
McConnell discloses a method of recognizing a pattern in a test object specifying properties characteristic of the pattern; specifying discrete ranges of values of the properties; measuring the values of the properties in the test object; arranging the measured values in at least one test histogram; determining a reference set of values of the properties and arranging the set as at least a first reference histogram; and comparing the test and reference histograms by determination of the value of a function which provides a measure of the amount of information necessary to express said at least one test histogram in terms of the optimum code for describing at least said first reference histogram.

Comments: *McConnell teaches invariant pattern search but not for high precision match. The histograms of different mapping regions could be independent of orientation and shape of object but it is the crudest representation of data, which is good for coarse but not high precision matching.*

C. Silver
Silver teaches a method and apparatus are provided for identifying differences between a stored pattern and a matching image subset, where variations in pattern position, orientation, and size do not give rise to false differences. The invention is also a system for analyzing an object image with respect to a model pattern so as to detect flaws in the object image. The system includes extracting pattern features from the model pattern; generating a vector-valued function using the pattern features to provide a pattern field; extracting image features from the object image; evaluating each image feature, using the pattern field and an n-dimensional transformation that associates image features with pattern features, so as to determine at least one associated feature characteristic; and using at least one feature characteristic to identify at least one flaw in the object image. The invention can find at least two distinct kinds of flaws: missing features, and extra features. The invention provides pattern inspection that is faster and more accurate than any known prior art method by using a stored pattern that represents an ideal example of the object to be found and inspected, and that can be translated, rotated, and scaled to arbitrary precision much faster than digital image re-sampling, and without pixel grid quantization errors. Furthermore, since the invention does not use digital image re-sampling, there are no pixel quantization errors to cause false differences between the pattern and image that can limit inspection performance.

Comments: *Silver's "perfect fit" method teaches away "digital image re-sampling"*

method. Instead, it teaches the use of vector-valued features because it cannot overcome digital grid quantization error inherent in the prior art method. It further teaches away of two stage approach since there is inherently no concept of coarse and fine matching in the vector-valued feature matching. Since Silver teaches away the digital image based matching method, it is not obvious for a person having ordinary skill of art to seek combination of the Kurosawa or McConnell with Silver due to the mis-match of prior arts.

D. Patentable Difference

Our current invention uses digital image representation yet it does not require and suffer any re-sampling error. This is because

1. We create matching function of subpixel values or invariant high precision parameters
2. The subpixel values or invariant high precision parameters can be estimated by image interpolation and interpolation parameter optimization.
3. The interpolation parameter optimization can be performed by an unique and efficient iterative matching function maximization.

Furthermore, using our invention, the same template can be used for initial matching and for the high precision matching.

E. Claim amendments

Applicant realize that we could improve the claims to clearly reflect the current invention. We amended the independent claims 1, 14, 17 and 20 to clearly state the unique inventive steps of the current invention. The amended claims added limitations reflecting the current invention that overcomes the cited prior arts. The applicant respectfully responds as follows:

Claims 1, 14, 17 and 20

(1) Step (c), added "containing only matching function values at discrete (x,y) positions" to clearly specify the content of the initial search result.
(2) Step (d), clarified interpolating the matching function values of discrete (x,y) positions.
(3) Step (e), clarified matching function values at discrete (x,y) positions create a high precision match result output without image matching.
(4) Step (e), clarified the high precision match result around a pixel position (x,y) is the subpixel values α and β and other parameters correspond to the maximum value of the high precision matching function.

Kurosawa's teaches matching of partial patterns (referred to as "reference segments"). The result of matching is for **unknown pattern recognition** to find the matched partial pattern candidates among the reference segment (column 4 lines 56-68; column 5 lines 1-

14. It is not for **known pattern position search** which finds the best position of a known pattern (a template). Therefore Kurosawa teaches away from our invention: unknown pattern recognition vs. known pattern position search.

McConnell teaches a simplified histogram, shown in its FIG. 2B where histogram cell count is independent of orientation or shape of objects within the field of view. But it is well-known that histogram does not preserve the spatial relationship of the template. So it is good enough for unknown pattern recognition but not for known pattern location search. Our implementation uniquely performs invariant matching that preserves the spatial relationship of the template for high precision search yet it does not require re-doing template matching. It performs optimization uses already existing matching function values at discrete (x,y) positions.

Silver teaches invariant matching by generating a vector-valued function using the pattern features to provide a pattern field; extracting image features from the object image; evaluating each image feature, using the pattern field and an n-dimensional transformation that associates image features with pattern features, so as to determine at least one associated feature characteristic. Silver does not teach invariant pattern matching using image template rather than vector

Neither Kurosawa nor McConnell or Silver teach the use of matching function of subpixel values or invariant high precision parameters. Neither do they teach the use of the same template for high precision match.

Applicants respectfully submit that the amended claims 1, 14, 17 and 20 clearly specify the essence of the invention that is unanticipated by the combination of Kurosawa, McConnell and Silver.

Claim 6 is canceled.

Claim 11
Examiner Bitar rejected claim 11 asserting Silver uses an iterative method for maximization performed using optimization method (Figures 22-25).

Silver FIGS. 22a give details of the solve module 1540 of FIG. 15, which produces the motion transform and the rms error value. The formulas shown are based on the solution of the least-squares problem of equation 15. Pattern parameters 220 specify which degrees of freedom are to be determined.

FIG. 22a shows the solution for the 2 translation degrees of freedom only--size and orientation are as specified in the start pose. FIG. 22b shows the solution for translation and orientation. This preferred solution is based on an approximation that assumes a small angle of rotation. If the assumption is violated, some size variation will be introduced. FIG. 22c shows the solution for translation and size, holding orientation

fixed, and FIG. 22d shows the solution for all 4 degrees of freedom. FIG. 23 gives details of the compose module 1505 of FIG. 15, which composes the current pose 2300 with the motion transform 2330 computed by the solve module 1540 to produce the new pose 2360.

FIG. 24 gives details of the normal tensor module 1510 of FIG. 15, which computes the normal tensor 2460 from the current pose 2400 and the client map 2430. FIG. 25 shows an example of field dipole evaluation performed as part of field dipole evaluation module 1550 of FIG. 15. In the example, a first image dipole 2500, second image dipole 2510, and third image dipole 2520 have received evaluations 0.85, 0.93, and 0.88 respectively. Four field dipoles labeled 2540, 2550, 2560, and 2570 lie along a chain as determined by connect step 254 during training module 110. The chain is defined by the left links 2580 and right links 2585.

As clear from the above description, applicant respectfully argues that Silver does not use an iterative method for maximization. Therefore, Claim 11 is unanticipated by Silver or the combination of Kurosawa, McConnell and Silver.

Claim 23

Applicants respectfully submit that the amended claim 20 clarifies the invention of claim 23.

Conclusion

In view of the above remarks and arguments, applicant submits that the amendments to claims overcome claim rejections under 35 USC §112, double patenting and 35 USC §103. Therefore applicant submits that this application is in condition for allowance, which action applicant respectfully solicits.

Conditional Request for Constructive Assistance

If for any reason this application is not believed to be in full condition for allowance, applicant respectfully requests the constructive assistance and suggestions of the Examiner pursuant to MPEP para. 707.07(j) in order that the undersigned can place this application in allowable condition as soon as possible and without the need for further proceedings.

Respectfully submitted,

Shih-Jong J. Lee